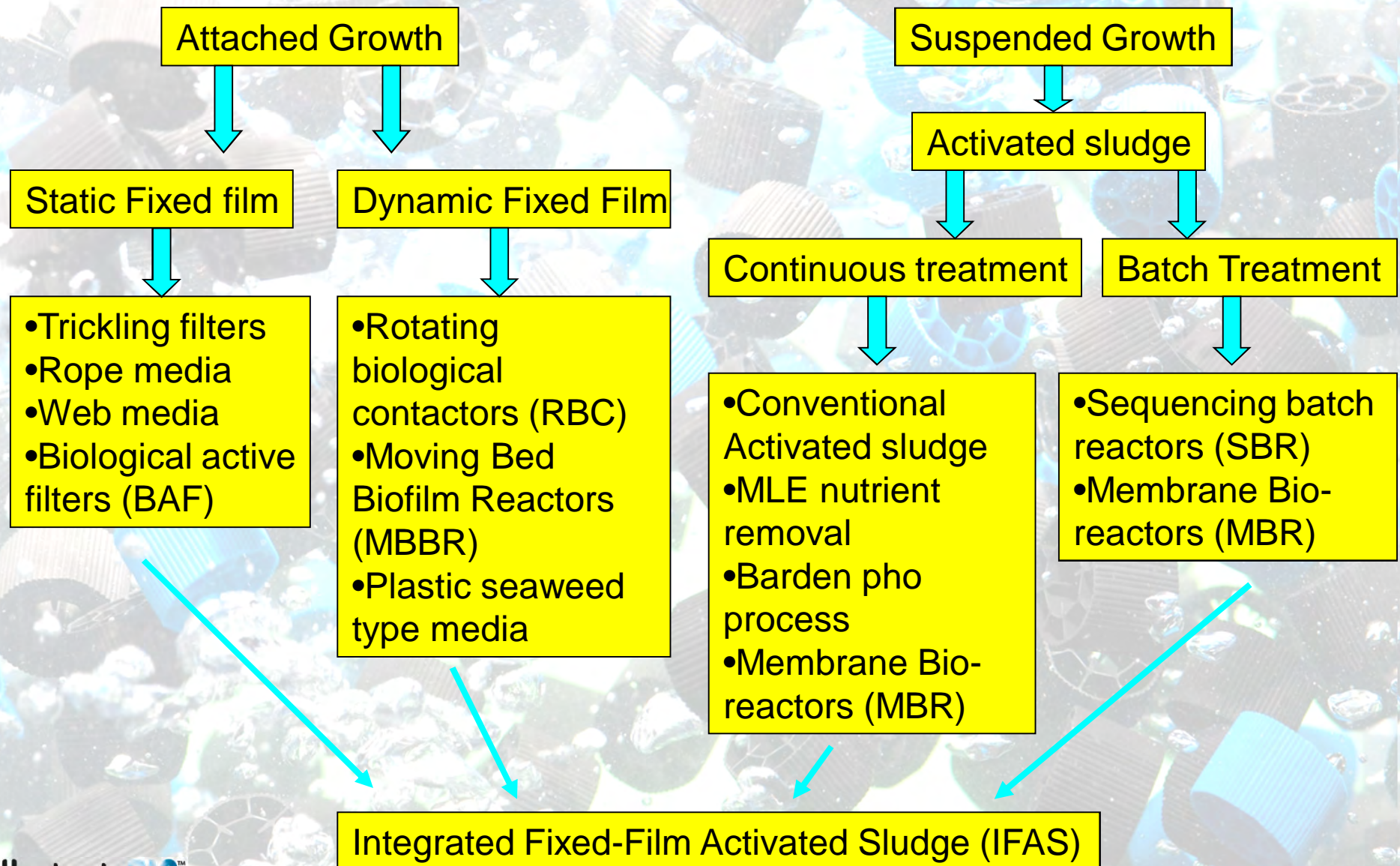




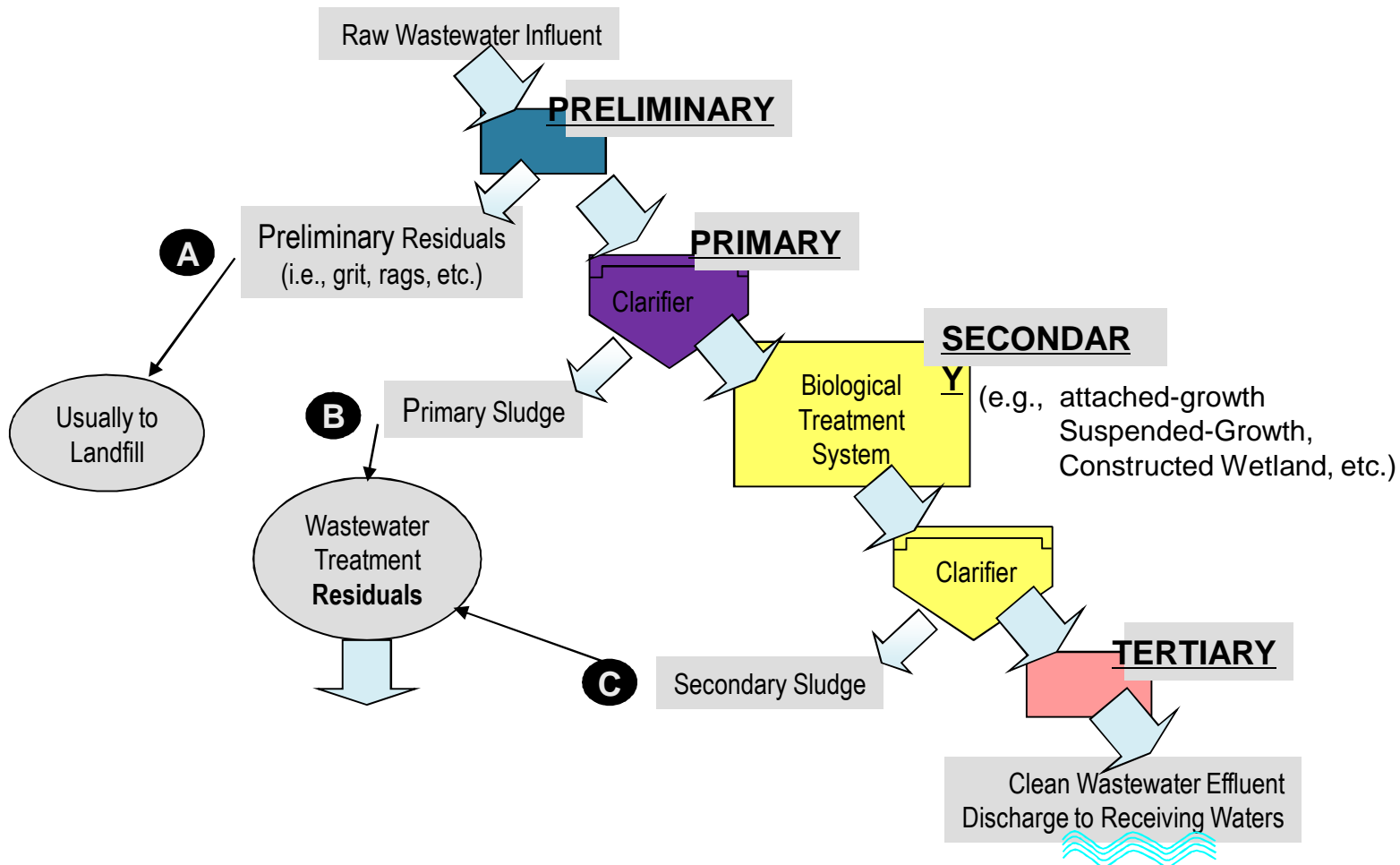
Advantages & Applications of MBBR Technologies

Headworks BIO™

Wastewater Technologies



General Overview of Plant's Components

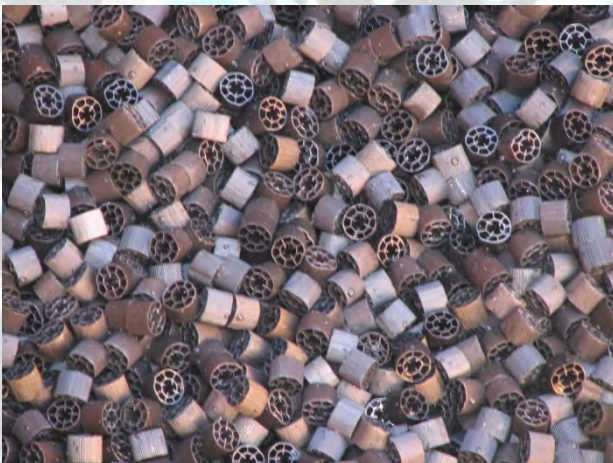


Fixed Film Technologies



Trickling filters are a static, air phase fixed film treatment system.

RBCs are partially water and air phase.



MBBRs are dynamic, water phase fixed film treatment systems



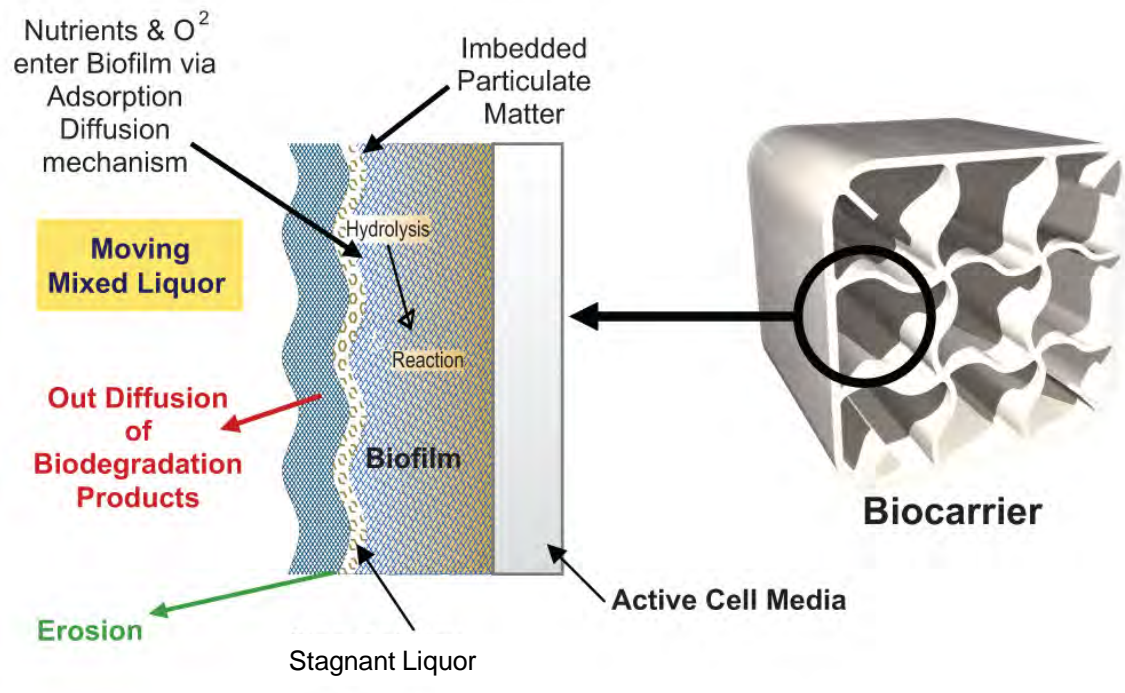
MBBR = Moving Bed Biofilm Reactor

- Headworks Bio Inc's process is based on the biofilm principle using polyethylene carrier elements.
- The carrier elements, which are less dense than water, 0.93-0.95 SG, provide a large protected surface for bacteria culture.
- MBBR provides advantages of Activated Sludge and Trickling Filter systems without their disadvantages.
- MBBR is one of the most documented processes with many technical publications and presentations.



Dynamic Water Phase Fixed Films

- No problems with odors, snails or red-worms as in air phase fixed films.
- Easier transfer of contaminants and oxygen to the biomass.
- Biofilm thickness is maintained and controlled by continuous sloughing created by the aeration-mixing process.
- NO attrition of media – plants 20 years old are still using original media



Biofilm Growth on Media

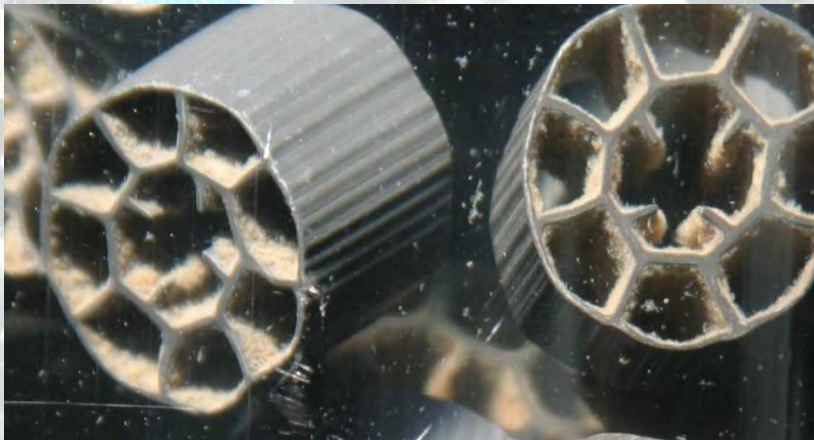
Mixing energy controls the biological thickness



BOD



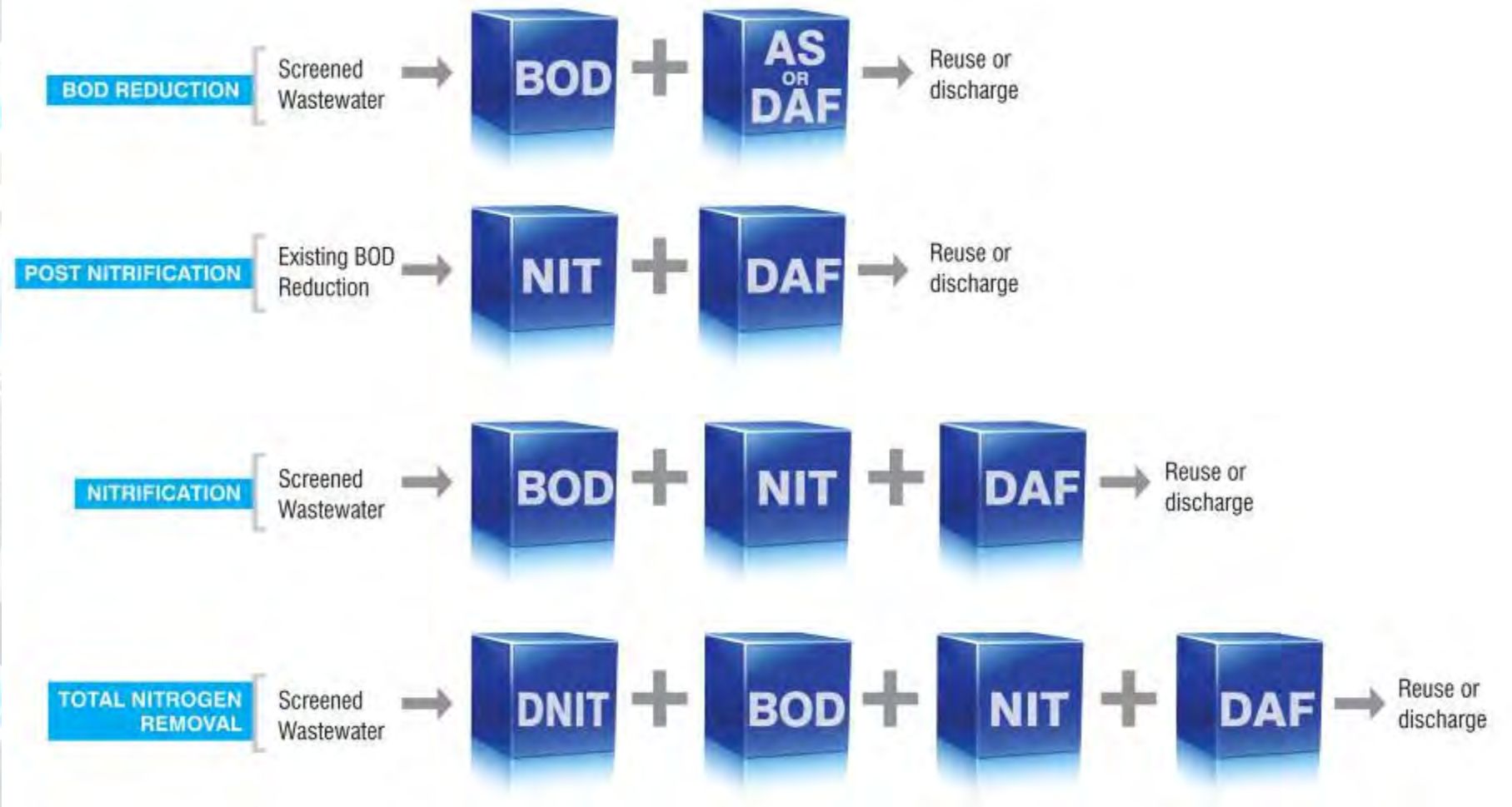
Nitrifiers



More Than Just Plastic



Customizable Processes

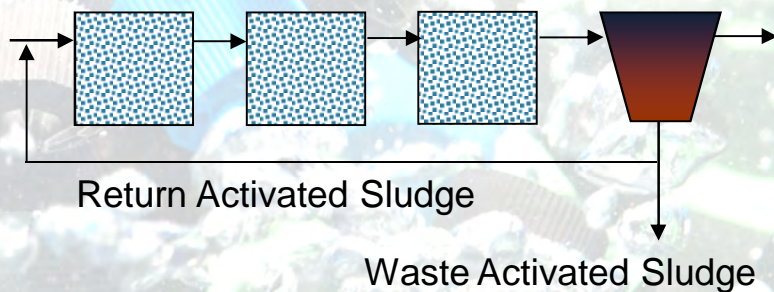


What's the Difference?

IFAS

Integrated Fixed Film Activated Sludge

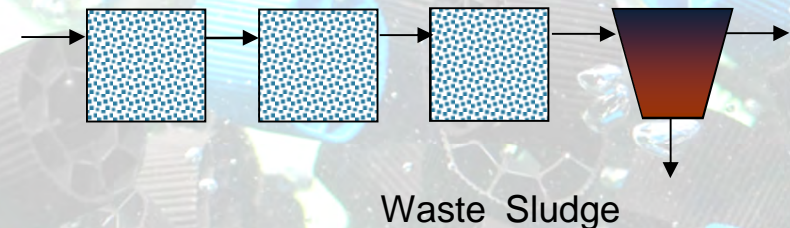
- ***Includes Return Activated Sludge (RAS)***
- Fixed film & Suspended growth



MBBR

Moving Bed Biofilm Reactor

- ***No RAS - "Once through" process***
- Fixed film Only



Why MBBR?

- Self regulating biomass.
- Flexible Design that allows for increased capacity.
- No operational adjustments, only equipment maintenance.
- Stable under large load variations.
- Smaller foot prints.
- Low investment Cost.
- Single pass treatment.
- Multiple applications.
- Extremely compact and simple biological treatment system.



Key MBBR Design Parameters

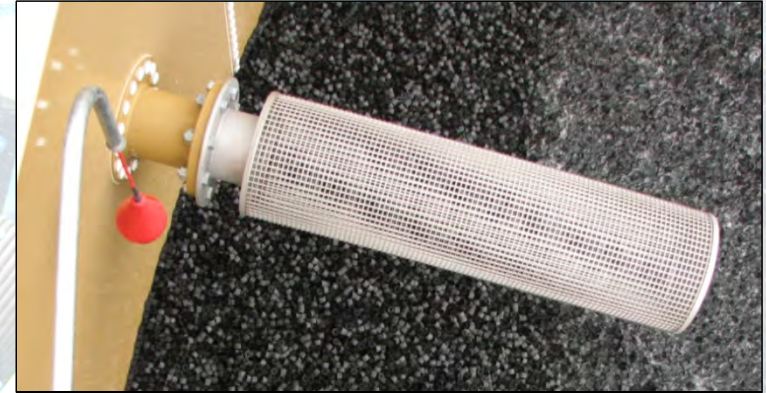
- Organic surface loading rate (g BOD/m²d)
Normal rate : 10 – 13 g BOD₅/m²d @25 °C
- Protected surface area of carrier (m²/m³)
400 – 680 m²/m³ for Headworks ActiveCell Media
- The Biomedia carrier filling fraction (%)
Normally : 50 – 67 % (minimum 30%)
- Temperature
 - $k_T = 1,07(T-10)$ (when $T = 5 - 10$ °C)
 - $k_T = 1,06(T-10)$ (when $T = 10 - 20$ °C)



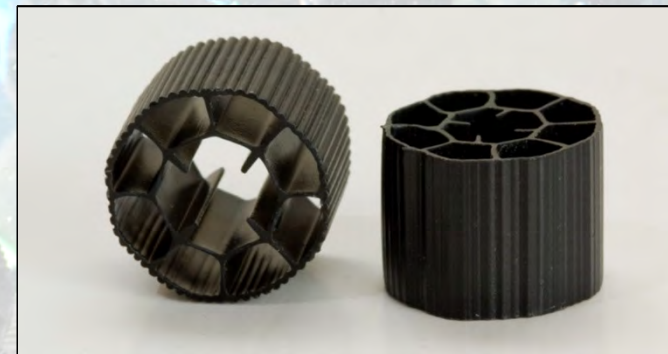
Key Components: MBBR



Aeration Grid



Retention Sieves



Activecell™ Media

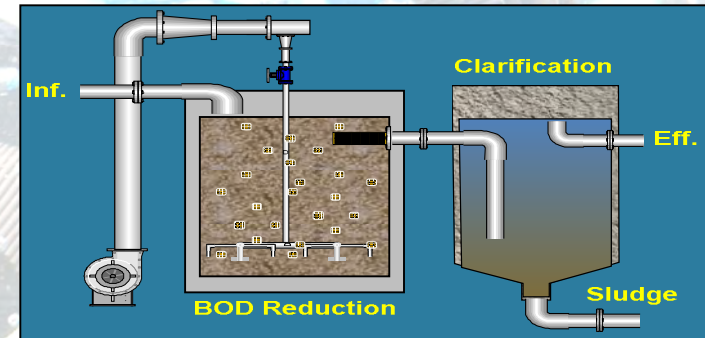
1% = Equipment Supply / 99% = Knowledge

Applications

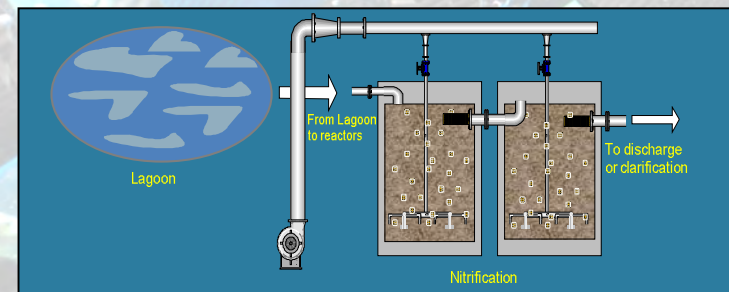
Features:

- Single pass treatment
- No operational adjustments
- Only equipment maintenance
- Self regulating biomass
- Small foot print
- Multiple applications

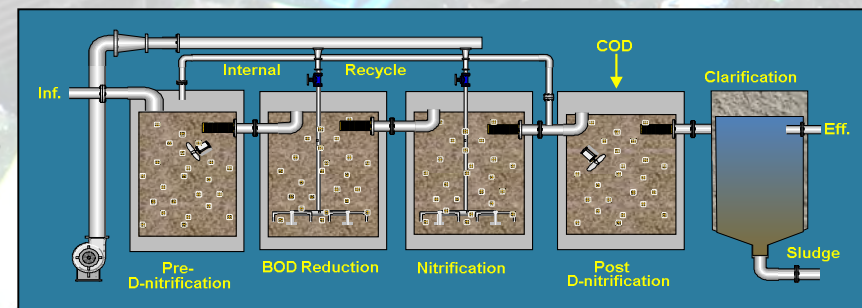
*BOD/COD
Reduction*



Nitrification

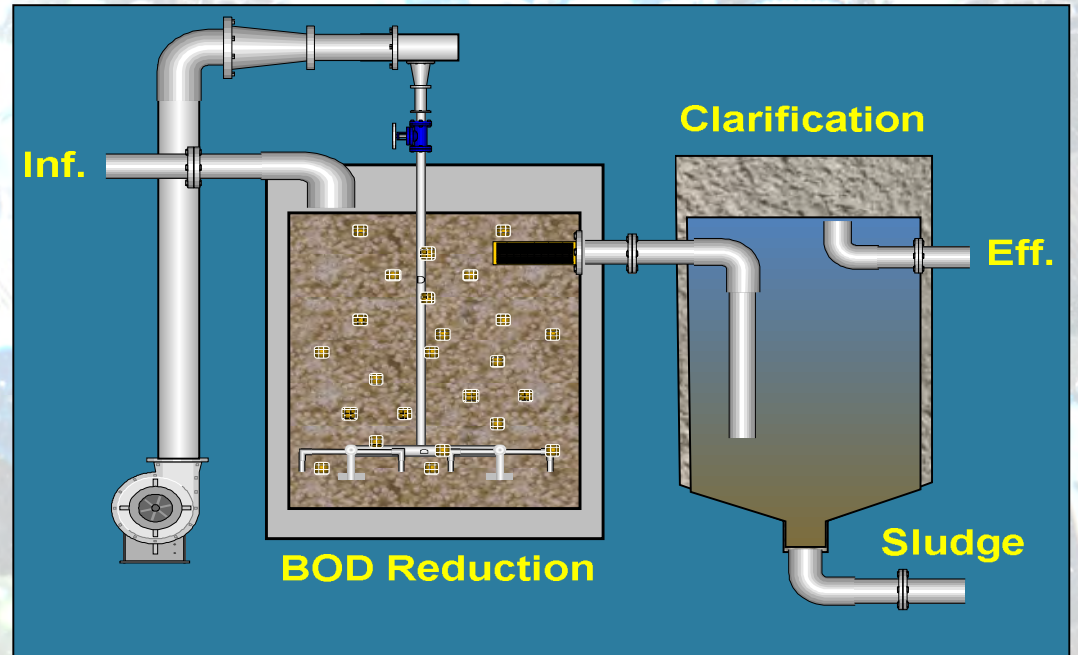


Denitrification



BOD / COD Removal

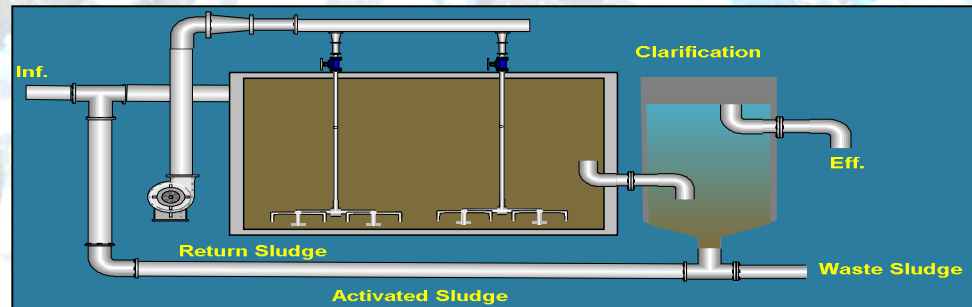
- High loads
- Up to 6000 mg/l
- Small foot print
- Single pass treatment
- No recycle
- No operator adjustments
- Biology self regulating
- Low BOD effluent
- 50% to 80 % reduction in 30 minutes
- < 10 mg/l BOD (after clarification)



IFAS Applications

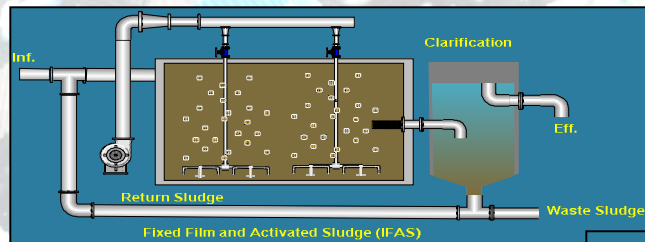
(works best at temperatures $< 25^{\circ}\text{C}$)

Existing Plant
BOD & TSS = 30 mg/L



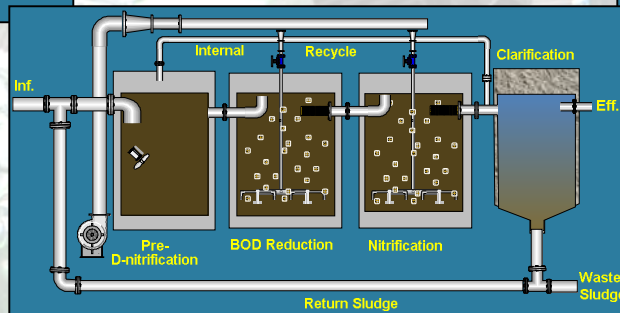
Nitrification Only

$\text{NH}_3\text{-N} < 1 \text{ mg/L}$



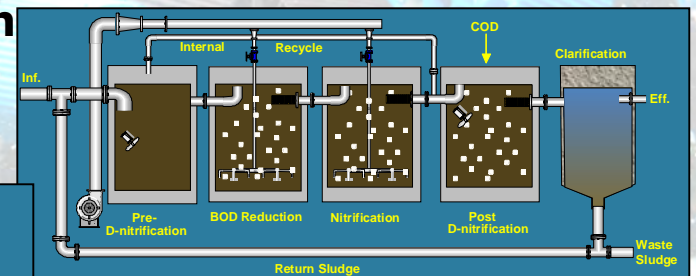
Pre-DN & Nitrification

$\text{NH}_3\text{-N} < 1 \text{ mg/L}$ &
 $\text{TN} > 8 \text{ mg/L}$



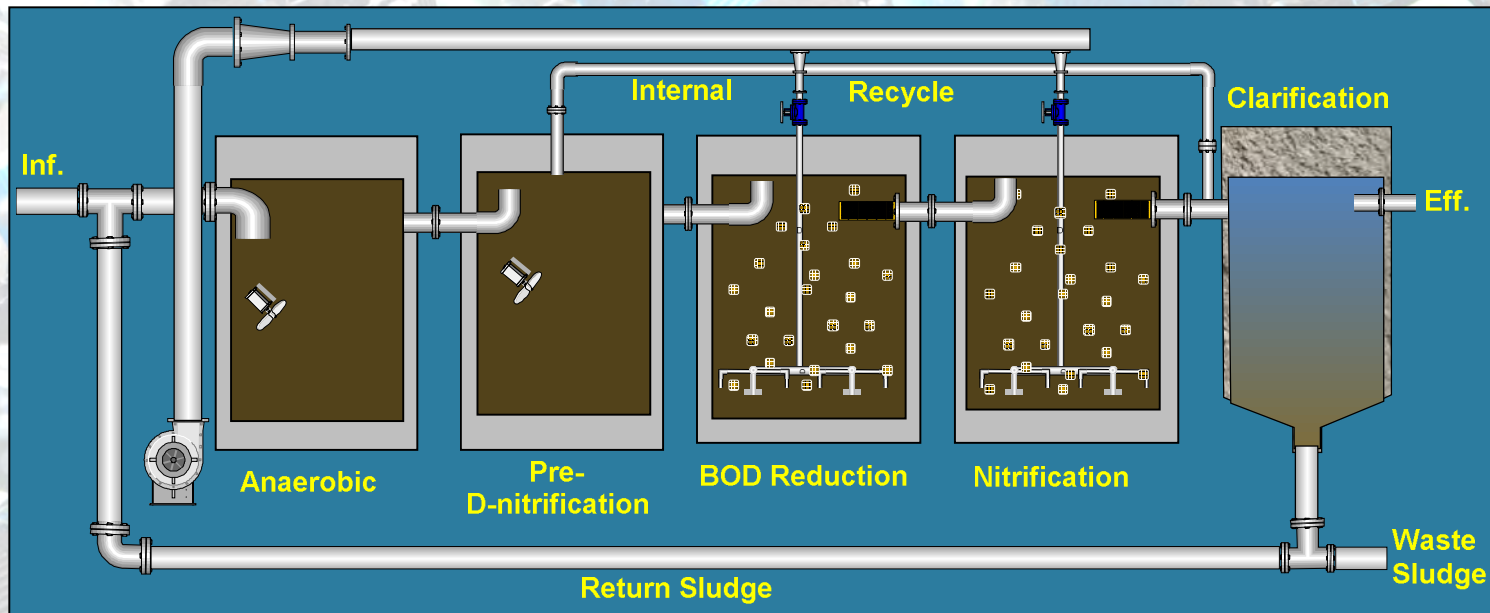
Pre & Post DN

$\text{NH}_3\text{-N} < 1 \text{ mg/L}$ &
 $\text{TN} < 3 \text{ mg/L}$



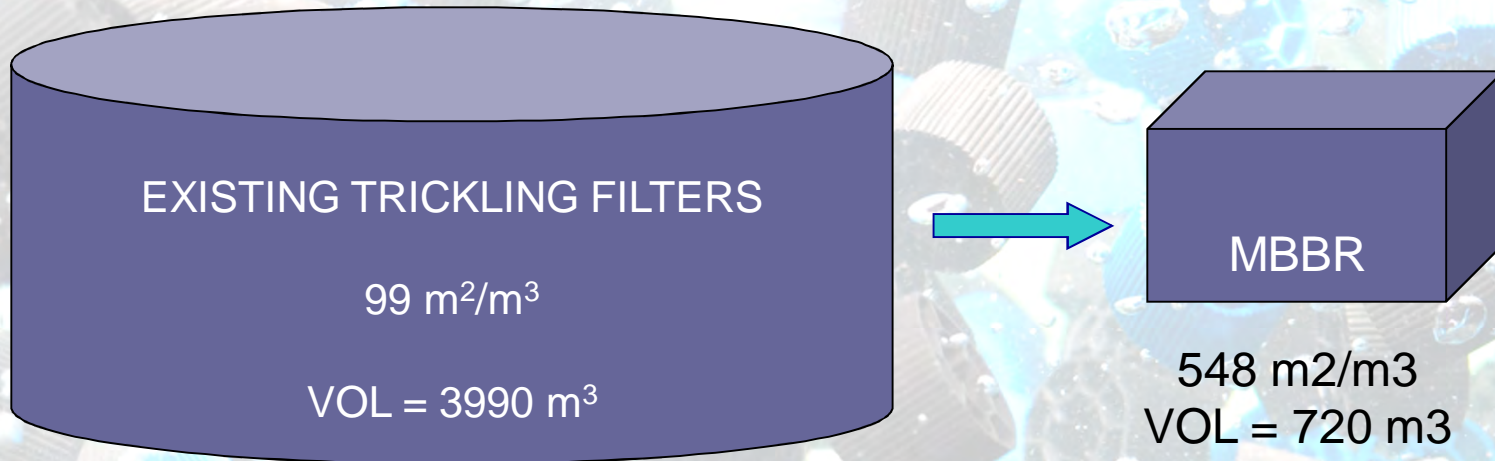
Biological Phosphorous Removal

- Decreases tank volume required for BOD/COD and Nitrification allowing room for Bio-P and De-nitrification.
- Allows for the suspended growth sludge age to be tailored for maximum phosphorus removal.
- Nitrification biology grows on media and is not affected by low sludge ages of suspended growth.



Footprint Comparison

Tricking Filter vs. MBBR

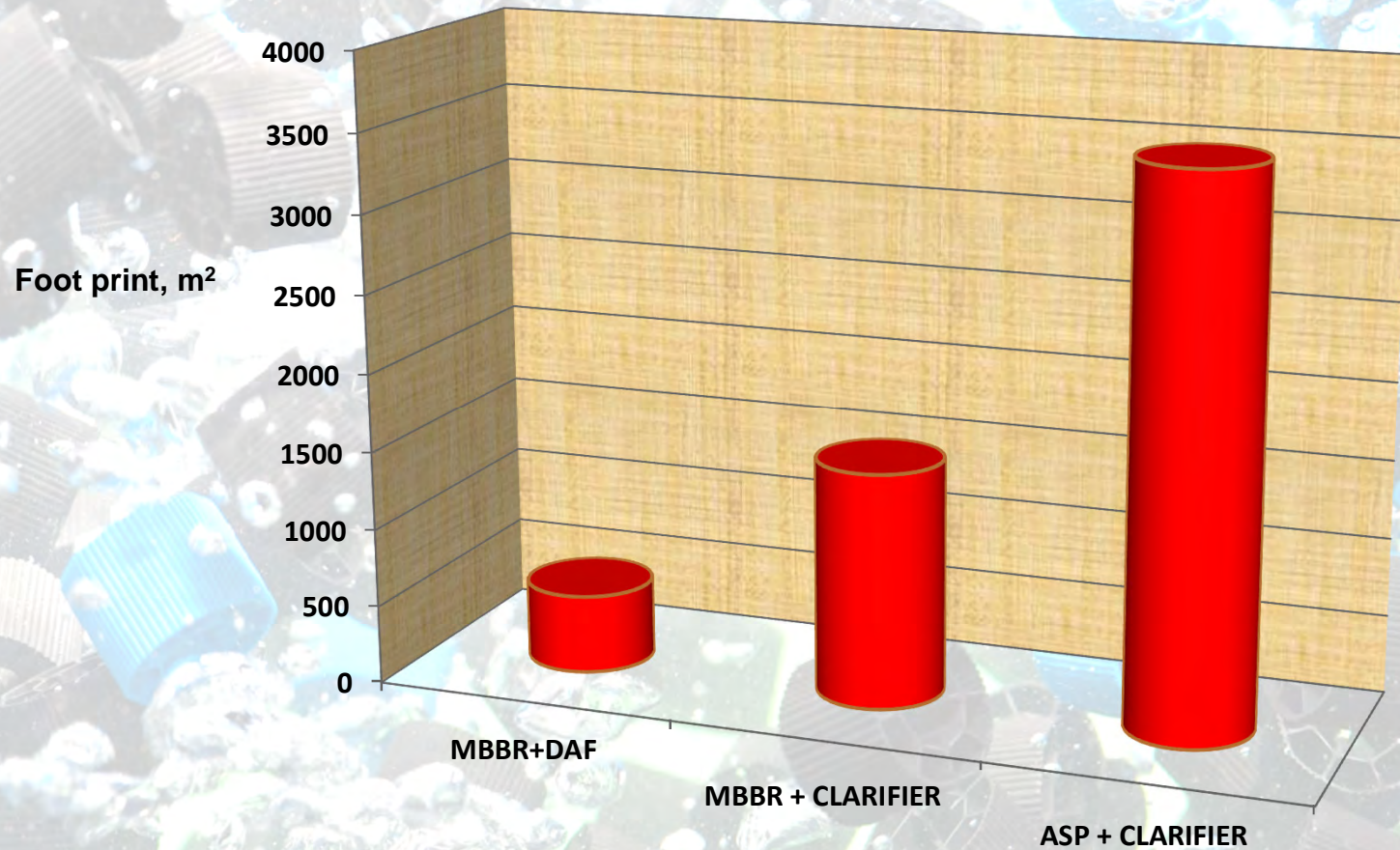


AT EQUAL LEVELS OF BOD REMOVAL:

MBBR Provides Five times the Biofilm Surface Area in less than $\frac{1}{4}$ Reactor Volume as Trickling Filter

Kinetics = MBBR is More Active & Efficient than Trickling Filter

Footprint comparison



RBC vs MBBR

Example Plant with 5000 m³/d design flow:

Influent: BOD: 600mg/l, COD: 1000 mg/l, TSS 600 mg/l

Effluent: BOD: 50 mg/l, COD: 80 mg/l, TSS 60 mg/l



RBC requires 800 m² area
and 93 kW for disk drives

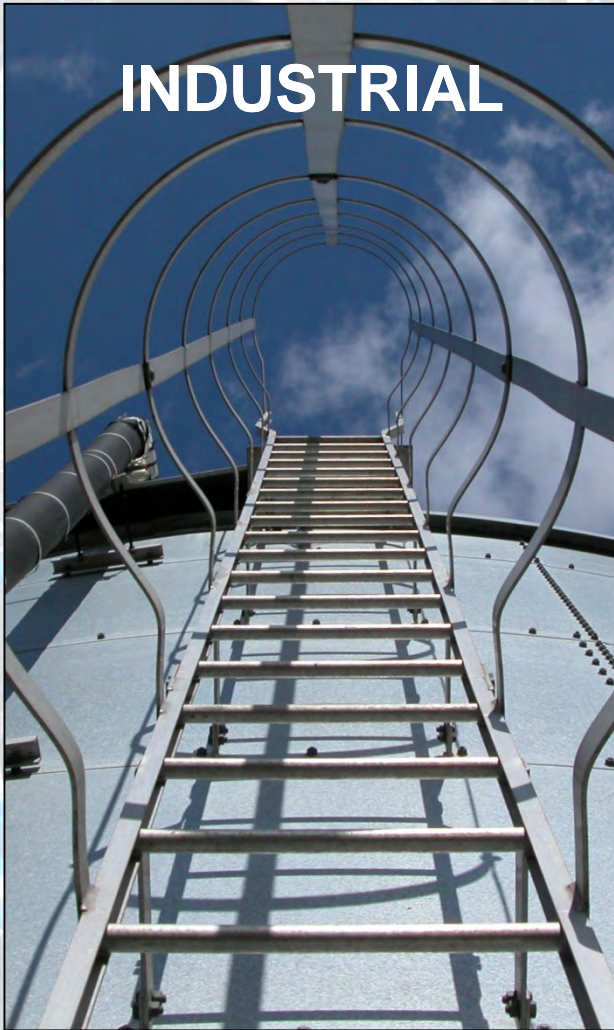


MBBR requires 195 m² area
and 93 kW for air blowers.

The power on the MBBR can be varied based
on the influent load where the RBC cannot.

MBBR Areas of Focus

INDUSTRIAL



MARINE

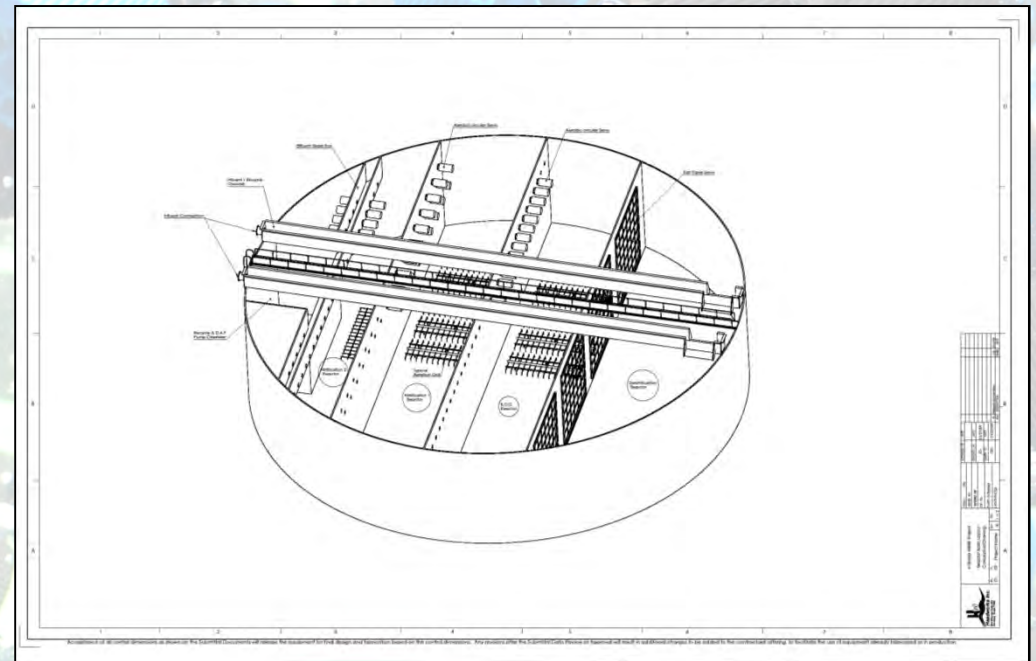


MUNICIPAL



MBBR Size vs. Activated Sludge

- Activated Sludge Extended Air process is designed for 12 to 24 hours hydraulic retention time (HRT).
- The MBBR need only 2 to 3 HRT to achieve the same level of nitrification.
- This is less than or equal to $\frac{1}{4}$ the tank volume.
- Typical biomass levels in activated sludge plants is between 2500 mg/l to 3500 mg/l of suspended solids.
- Typical equivalent biomass in an MBBR is 6000 mg/l of attach growth.
- This is 2 times more available treatment mass.



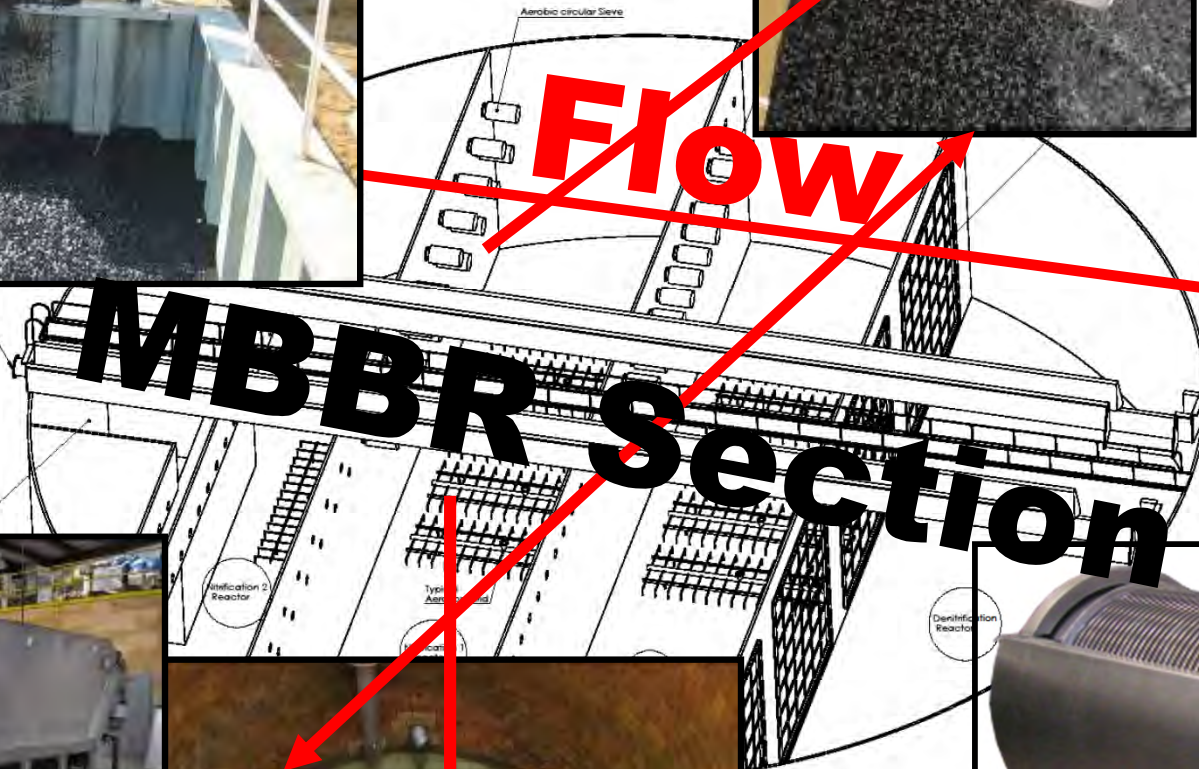


**Tertiary
Treatment**

(Sandfilter)

DAF

(Clarifier)



40m Diameter, 9m high – 40 000m³/d

Carousel Upgrade

(Typical Saudi Arabian Wastewater Plant)

Current Design

- Capacity: 25,000 m³/d
- Effluent Quality: ?

Option 1

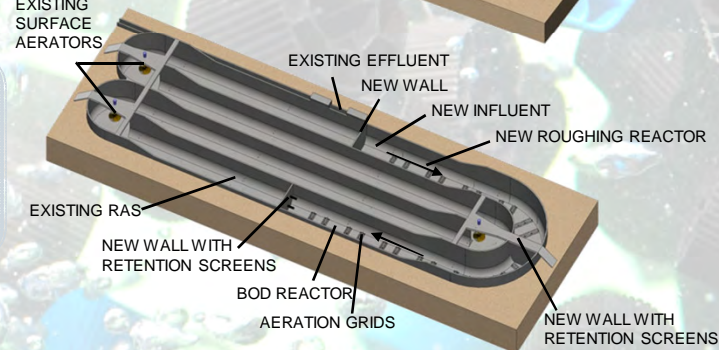
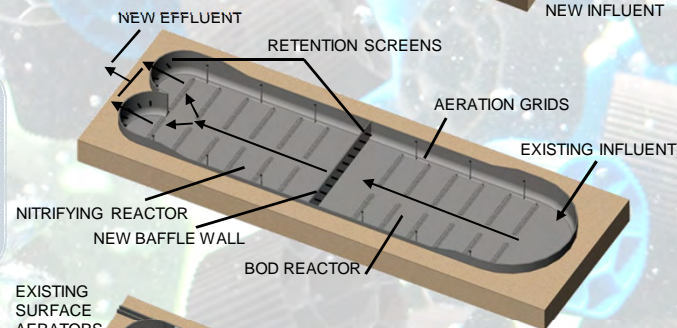
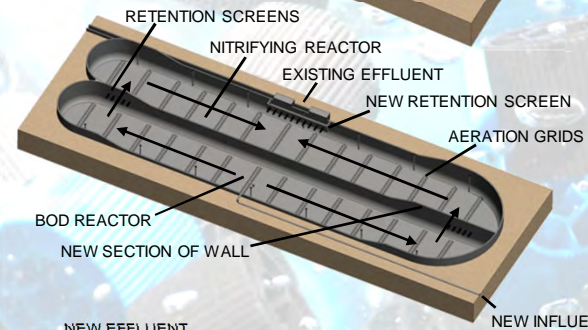
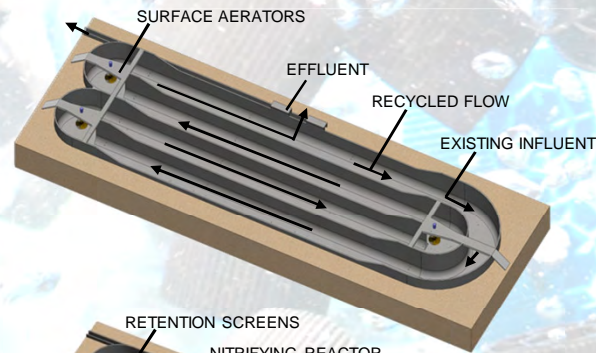
- Capacity Increases to 45,000 m³/d
- Effluent Quality: 10/10/3*

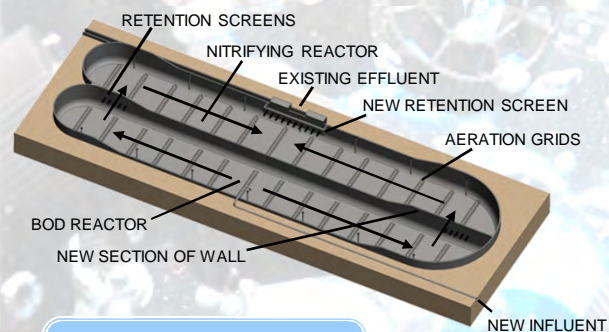
Option 2

- Capacity Increases to 90,000 m³/d
- Effluent Quality: 10/10/3*

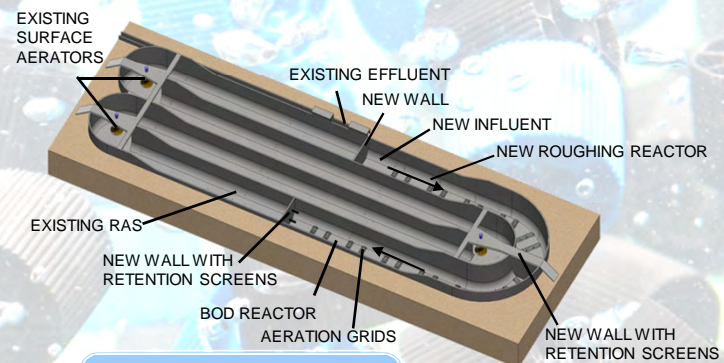
Option 3

- Capacity Increases to 45,000 m³/d
- Effluent Quality: 10/10/3*

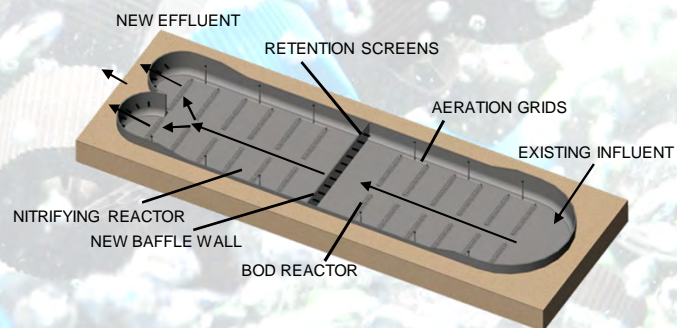




Option 1



Option 3



Option 2

	Options for Upgrading Carousel System		
	1	2	3
Increase in Treatment Capacity	2X	4X	2X
% Media Fill	30%	60%	40%
Number of Internal Walls Removed	2	3	None
Number of New Internal Walls	1 Short	1	3 Short
New Influent Location	No	Yes	No
New Effluent Location	No	Yes	No
% Retrofit Existing Tank with Diffused Aeration System	100%	100%	25%
Remove Existing Surface Aerators	Yes	Yes	No

Capacity Increase

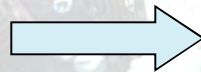
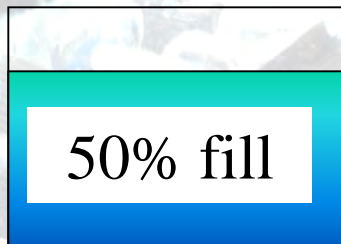


Flow increase of 4 x 250 m³/d up to 4 x 1000 m³/d

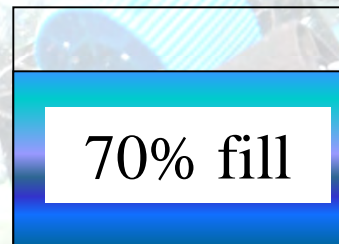
Phased increase in capacity

Existing plant capacity can be increased by adding more media into the MBBR Tank

Existing
MBBR



After



Flow = 1000 m³/d

BOD Load = 300 kg/d

Fill fraction = 50 %

Flow = 1400 m³/d

BOD Load = 420 kg/d

Fill fraction = 70 %



Moorhead, MN: 22,750 m³/day



Agnico Eagle LeRonde Mine: Cadillac, Quebec



Jamaica: 8,000 m³/day

- Three ActiveCell bioreactors in series designed for BOD and Nitrification to less than 10 mg/L and < 2 mg/L respectively.
- Dissolved Air Flotation (DAF)
- Chlorination and sand filtration prior to re-use as cooling tower make-up.
- A portion of the filtered flow is de-mineralized prior to re-use as boiler feed water.



Finland: 18,500 m³/day



Marine Installations

CleanSea® Shipboard Wastewater Treatment



RCCL Vision of the Seas



Celebrity Millennium



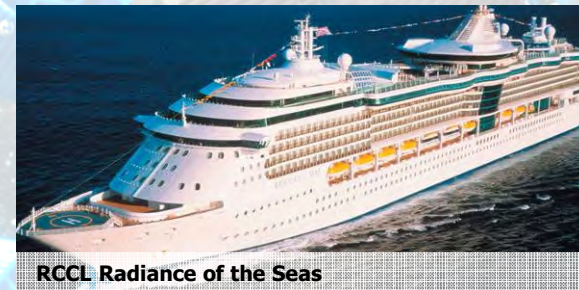
Celebrity Summit



RCCL Enchantment of the Seas



RCCL Jewel of the Seas



RCCL Radiance of the Seas



Celebrity Constellation



RCCL Brilliance of the Seas



RCCL Project Genesis

Onboard the Largest Cruise Ship in the World



Passengers & Crew ~8,400
Hydraulic Capacity 3,000 m³/day 0.79 MGD
Typical Flow 2,000 m³/day 0.53 MGD
Max. Influent BOD Max. Influent TSS
~1,500 mg/L ~850 mg/L
Effluent BOD Effluent TSS < 15 mg/L < 15 mg/L

Extensive Installation List

Installations including municipal in the following industries:

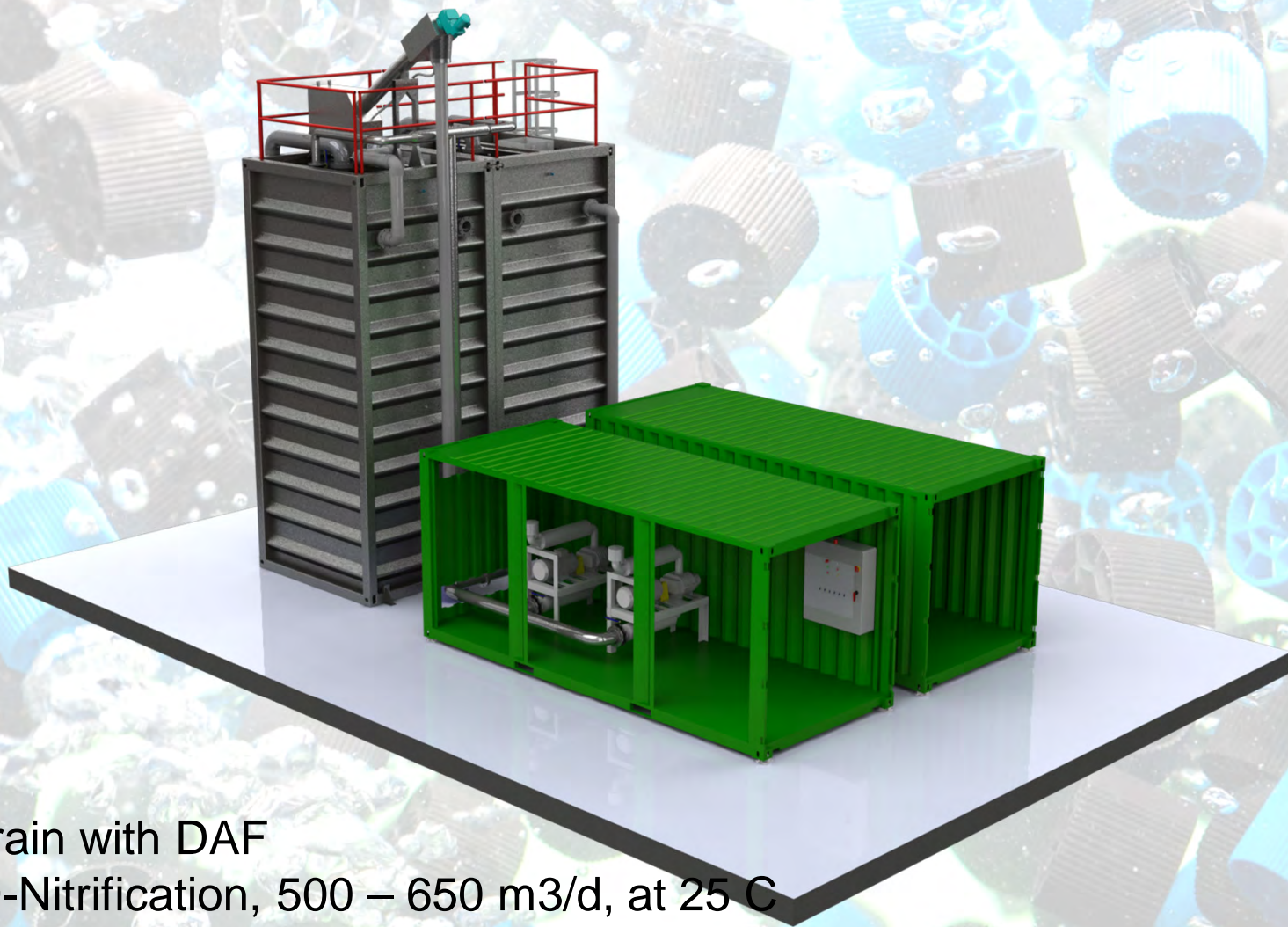


- Domestic/Resort
- Food Processing
- Landfill Leachate
- Marine
- Meat Processing
- Mining
- Petrochemical
- Pharmaceuticals
- Power Plant
- Pulp & Paper
- Septage Processing
- Vehicle Wash



HIT System™

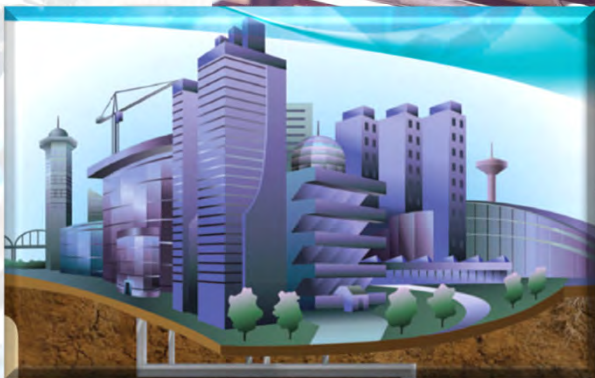
Headworks Integrated Treatment System



Single Train with DAF
DN-BOD-Nitrification, 500 – 650 m³/d, at 25 C

HIT System™

Headworks Integrated Treatment System



**Flow: (60 m³/day) Influent:
300/300/40 Effluent: 10/10/2**

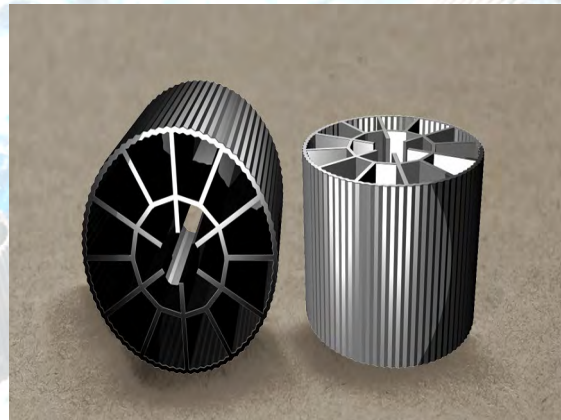
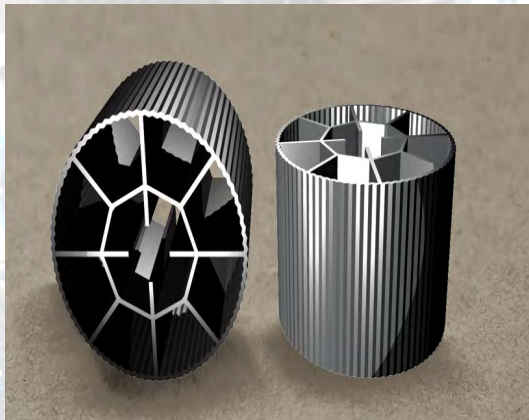
Comparison: MBR vs MBBR

	MBR Plant	MBBR Plant
Capital Investment	High	Low
Footprint	Low	Low
Flow Tolerance	Low	High
Aeration Blowers	Required	Required
Recirculation Pumps	Required	Not Required
Air Scouring Blowers	Required	Not Required
Screening Requirements	High	Low
Chemical Usage	High	N/A
Operational Difficulty	High	Low

Comparison: 800 m³/day

MBBR	RBC	Activated Sludge	SBR
No residual suspended solids	No residual suspended solids	Requires residual suspended solids (MLSS)	Requires residual suspended solids (MLSS)
Self regulating, no operator adjustments	Self regulating, no operator adjustments	Operator adjusts MLSS levels	Operator adjusts MLSS levels
Single pass flow through	Single pass flow through	MLSS sludge recycled back through plant	May or may not require MLSS recycle
1 hour retention time (based on 800m ³ /d)	4 hours retention time	4 hours retention time	5 hours retention time (includes clarification)
8.25 m ² treatment area	64 m ² treatment area	33.75 m ² treatment area	31.5 m ² treatment area (includes clarification)
Not affected by high flows	Biology stripped of media with high flows	MLSS can be flushed out with high flows	Rarely affected by high flows
Low mechanical equipment	High mechanical equipment	Moderate mechanical equipment	Low mechanical equipment
Stable nutrient removal	Unstable nutrient removal	Unstable nutrient removal	Stable nutrient removal

Which Activecell media has the larger protected surface area?



???





Questions?

Headworks BIO

International
Headquarters
800 Wilcrest Dr, Suite
340
Houston, TX 77042
hwbio@headworksusa.
www.headworksbio.com